Pronounced inpact of salinity on rapidly intensifying tropical cyclones

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1. Introduction and Motivation

Rapid Intensification (RI), defined as an increase in intensity of at least 30 knots in a 24 hour period, is a process of explosive strengthening undergone by most of the very intense hurricanes. While warm sea surface temperatures (SSTs) and high upper-ocean heat content are well-known to favor RI, the role of salinity has hitherto not been explored.

Objective:

- Using a suite of observations and numerical model simulations, explore and identify the influence of salinity on hurricane RI.

2. Results

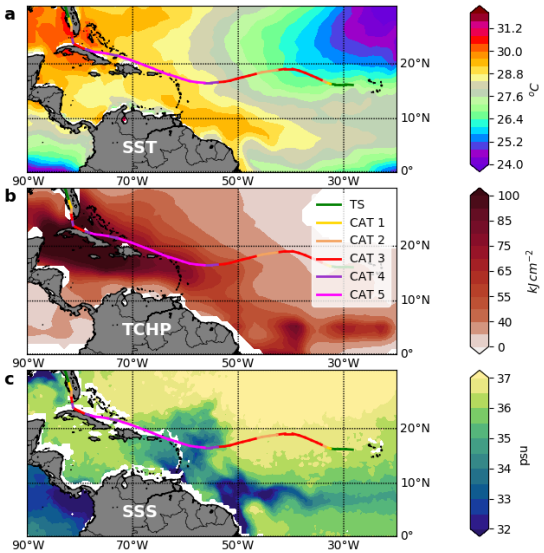

Figure 1: Prevailing upper-ocean conditions during August 2017, with the track of Hurricane Irma overlaid. a) SST (°C) b) TCHP (kJ cm^{-2}) and c) SSS (psu).

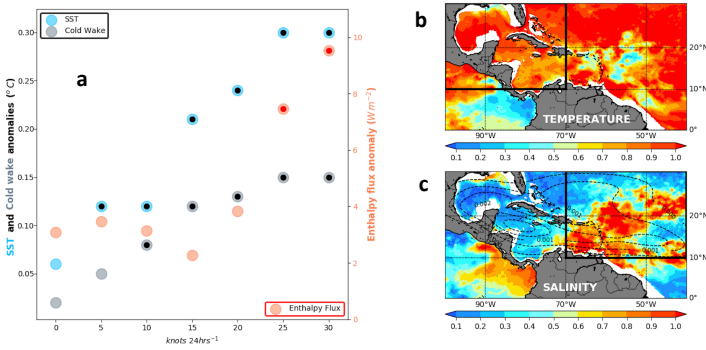

Figure 2: a) Anomalous mean pre-storm SST, cold wake and enthalpy flux for Atlantic hurricanes as a function of intensification threshold. Concentric smaller dark circles indicate significance at the 95% level. Coefficient of linear regression between hurricane-season mean density stratification and b) temperature stratification and c) salinity stratification. Dashed contours in (c) represent RI locations.

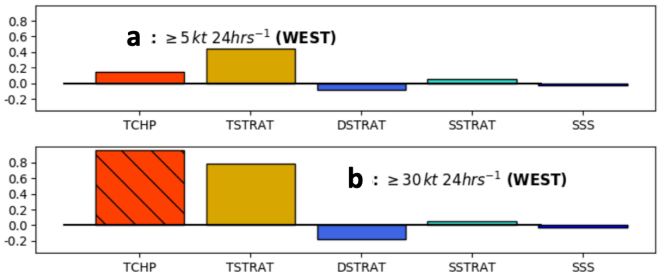

Figure 3: Anomalous mean TCHP (kJcm^{-2}), temperature stratification (TSTRAT, °C), density stratification (DSTRAT, kg m^{-3}), salinity stratification (SSTRAT, psu) and pre-storm SSS (psu) for situations where 24-hr intensity change is greater than or equal to a) 5 knots and b) 30 knots (RI). For various parameters, when the mean for the sub-sampled data is statistically different from the total mean, it is indicated using hatching. The analysis domain is the western sub-region shown in panel (b) of Fig. 2

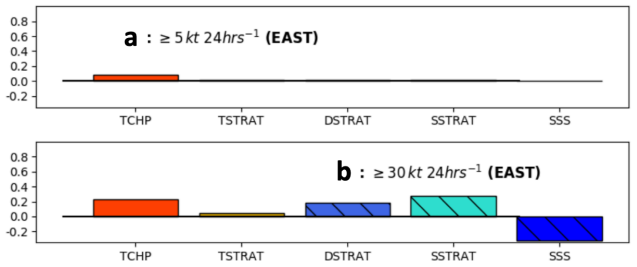

Figure 4: Anomalous mean TCHP (kJcm^{-2}), temperature stratification (TSTRAT, °C), density stratification (DSTRAT, kg m^{-3}), salinity stratification (SSTRAT, psu) and pre-storm SSS (psu) for situations where 24-hr intensity change is greater than or equal to a) 5 knots and b) 30 knots (RI). For various parameters, when the mean for the sub-sampled data is statistically different from the total mean, it is indicated using hatching. The analysis domain is the eastern sub-region shown in panel (c) of Fig. 2

3. Conclusions

Compared to weaker intensification, during RI the mean intensity of the TC is considerably higher and the vertical mixing induced by the storm extends considerably deeper, allowing ocean stratification effects to play a role.

In regions of strong spatial gradients in salinity, such as the western tropical Atlantic, salinity impacts RI through its influence on upper-ocean density stratification.

These observational results are supported by numerical experiments performed using the PWP ocean model.

Simulations using a statistical classification scheme reveal that the inclusion of salinity stratification could potentially improve RI forecasts.

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